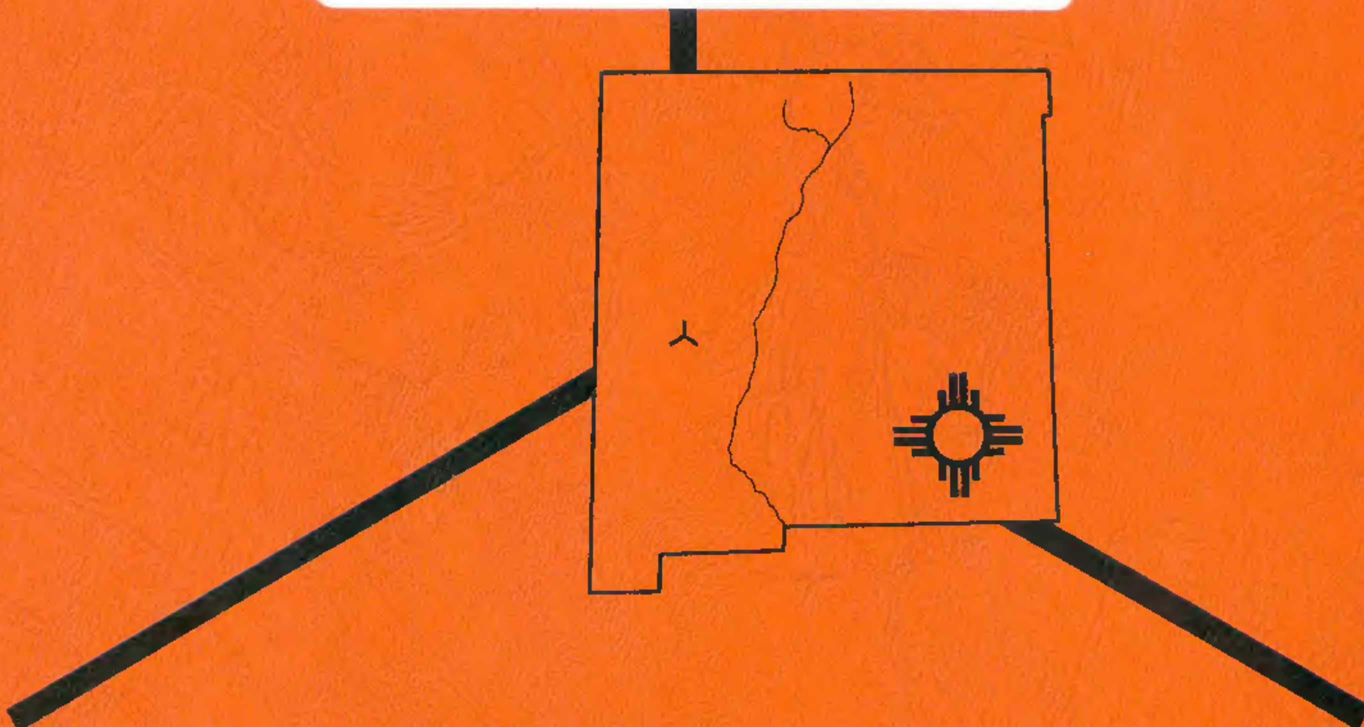
VERY LARGE ARRAY PROGRAM

VLA TECHNICAL REPORT NO. 48

MODULE T4C BASEBAND FILTER

W. E. Dumke

December 1980



NATIONAL RADIO ASTRONOMY OBSERVATORY
P.O. Box O, Socorro, New Mexico 87801

OPERATED BY ASSOCIATED UNIVERSITIES, INC.
UNDER CONTRACT WITH THE NATIONAL SCIENCE FOUNDATION

VLA TECHNICAL REPORT NO. 48

MODULE T4C BASEBAND FILTER

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CONTENTS

1.0 GENERAL DESCRIPTION

The T4C Baseband Filter modules provide the final analog filtering for the IF signals after down conversion to a baseband 200 KHz to 50 MHz range in the T3 IF to Baseband Converter module. The filtered signals are then amplified by the T5C Baseband Driver and transmitted to the D1 Sampler modules in the Screen Room for analog to digital conversion.

Filtering takes place with low pass filters in octave step bandwidth reduction from 46 MHz to 0.719 MHz. A 0.201 to 0.390 MHz bandpass filter is used for the narrowest bandpass range. Refer to Block Diagram C13820B2D for further details.

2.0 CIRCUIT DETAILS

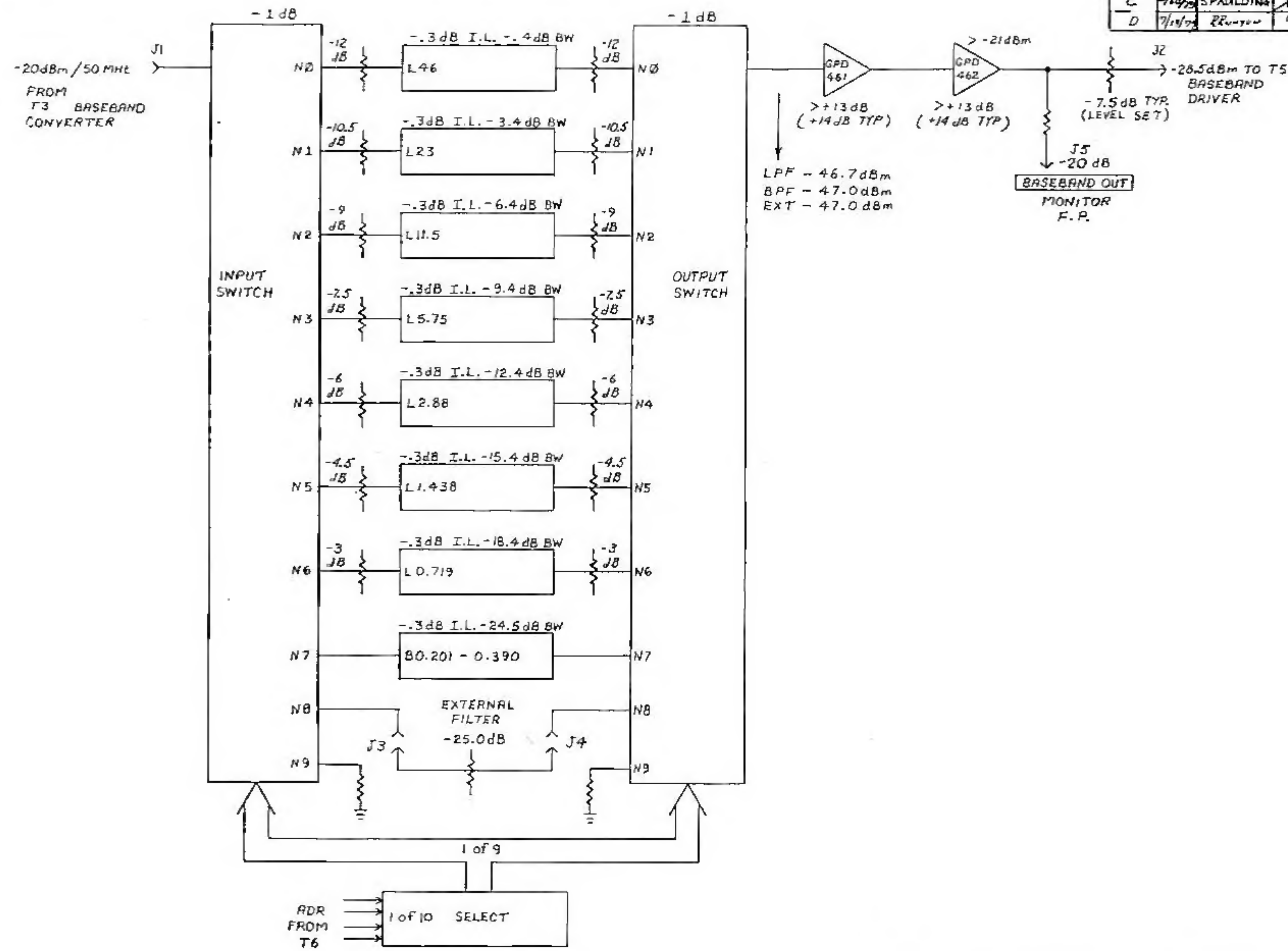
Most of the T4C circuitry is mounted on a single double sided PC board. Refer to D13820S3D for details. The module schematic is given in D13820S13.

2.1 Module Shielding and Filtering

Because of the operating frequency range of 200 KHz to 50 MHz in the T4C and T5C baseband system, special precautions had to be taken to insure adequate shielding and filtering to prevent interference from LO and digital signals. Special modules were designed with shielding as the prime concern. To prevent interference from LO signals (5 MHz and above) the module was designed with tight fitting lids (with eleven fastening screws rather than the usual six), and all inputs and outputs filtered, through shielded compartments. All power supply lines are filtered with π section low pass feedthrough filters. All digital signals are fed through 0.01 μF feedthrough capacitors to not degrade rise and fall times excessively. No wires or cables enter or leave the chassis without feedthrough filtering or proper grounding. This prevents signals entering the module flowing on the outsides of coax, for example.

However, even these steps proved inadequate for lower frequency interference from the fundamental and harmonics of

REV.	DATE	DRAWN BY	APPR'V'D BY	DESCRIPTION
A	7/29/77	R. Runyon	L. S. D.	ADDED 'J' DESIG.
B	4/21/77	R. Runyon	L. S. D.	CHG. OUTPUT LEVELS
C	7/20/79	SPAULDING	[illegible]	LABELING CHGS.
D	7/19/79	R. Runyon	L. S. D.	CORRECTED DWG ERROR



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES: ANGLES ±
3 PLACE DECIMALS (.XXX): ±
2 PLACE DECIMALS (.XX): ±
1 PLACE DECIMALS (.X): ±

MATERIAL:

FINISH:

PROJECT: T4-C

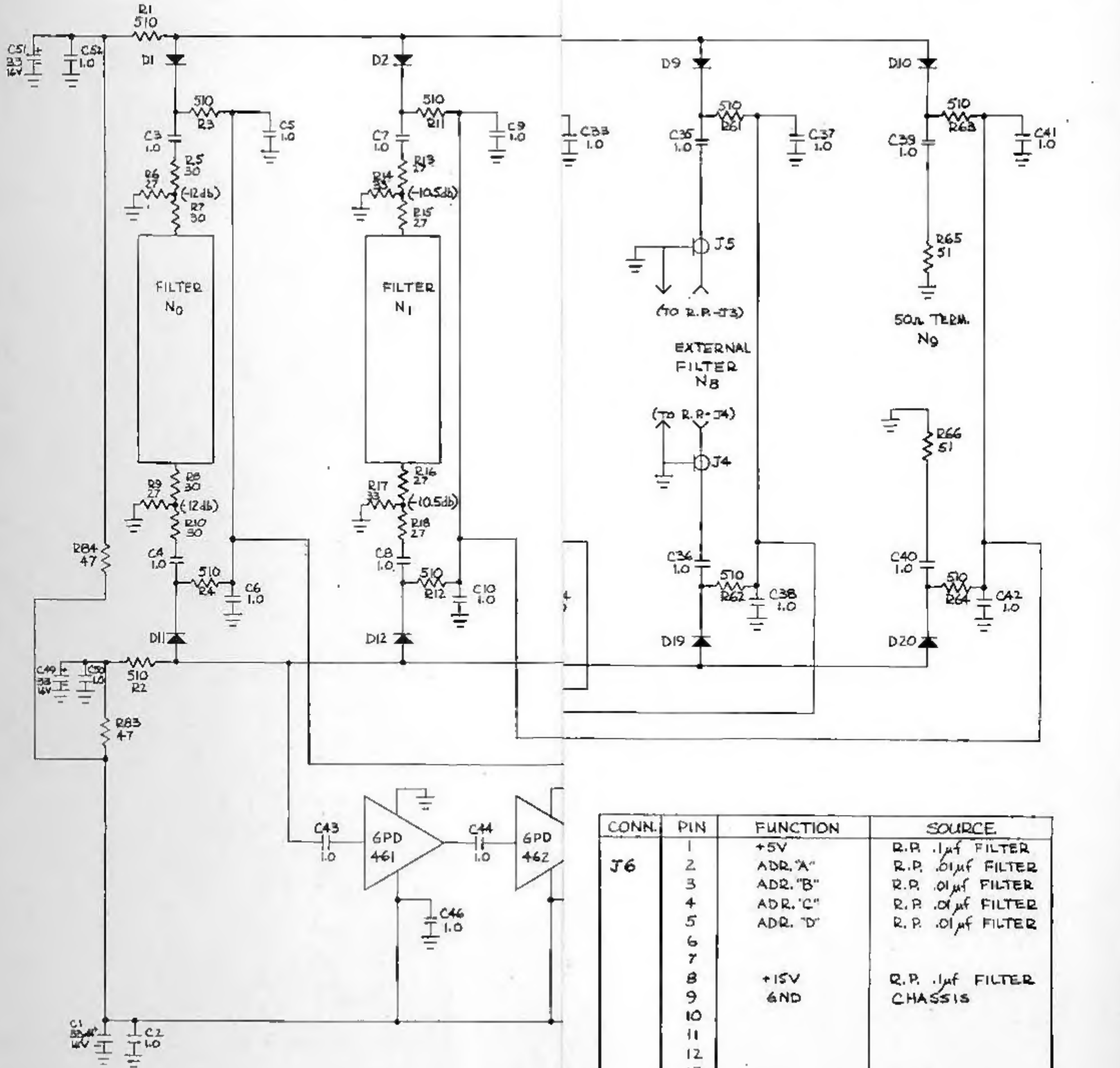
TITLE: BASEBAND FILTER (BLOCK DIAGRAM)

NATIONAL RADIO ASTRONOMY OBSERVATORY
SOCORRO, NEW MEXICO 87801

DRAWN BY [signature] DATE 2/14/78
DESIGNED BY W. E. DUMKE DATE 26/1/78
APPROVED BY [signature] DATE [illegible]

SHEET NUMBER
DRAW NUMBER ...2082
REV. D

REV.	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
A	12-12-78	SPAULDING	G.S.D.	CHG. ALL CAP VALUES; CHG. RESISTOR VALUES R54, R57, R70, R71; ADD CONN. INFO. BLOCK
B	4/20/79	SPAULDING	G.S.D.	ADD C53, C49, C50, C51, C52 ADD R83, R84
C	5/24/79	R.Benson	G.S.D.	CHG: R67 R68 & R69 VALUES AND ASSOC LEVELS
D	4/26/79	SPAULDING	[illegible]	LABELING CHGS.



CONN.	PIN	FUNCTION	SOURCE
J6	1	+5V	R.P. .1µf FILTER
	2	ADR. "A"	R.P. .01µf FILTER
	3	ADR. "B"	R.P. .01µf FILTER
	4	ADR. "C"	R.P. .01µf FILTER
	5	ADR. "D"	R.P. .01µf FILTER
	6		
	7		
	8	+15V	R.P. .1µf FILTER
	9	GND	CHASSIS
	10		
	11		
	12		
	13		
	14		
J1		RF INPUT	R.P J1
J2		RF OUTPUT	R.P-J2
J3		BASEBAND OUT	F.P. BNC
J4		EXT. FILTER OUT	R.P. J4
J5		EXT. FILTER IN	R.P. J3

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NSIONS ARE IN INCHES
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E DECIMALS (.X) ±
IAL:

PROJECT: T4-C FILTER BASEBAND

TITLE: FILTER P.C. CARD SCHEMATIC

NATIONAL RADIO ASTRONOMY OBSERVATORY
SOCORRO, NEW MEXICO 87801

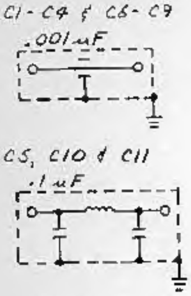
DRAWN BY GENE SPAULDING, DATE 8-24-78
DESIGNED BY BILL DUMKE, DATE 8-22-78
APPROVED BY [illegible], DATE 7/31/78

SHEET NUMBER 1 of 1 — DRAWING NUMBER D1382053 — REV. D

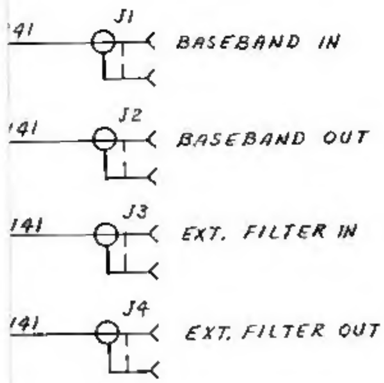
REV.	DATE	DRAWN BY	APPR'V'D BY	DESCRIPTION
A	4/20/79	SPAULDING		LABELING CHGS.

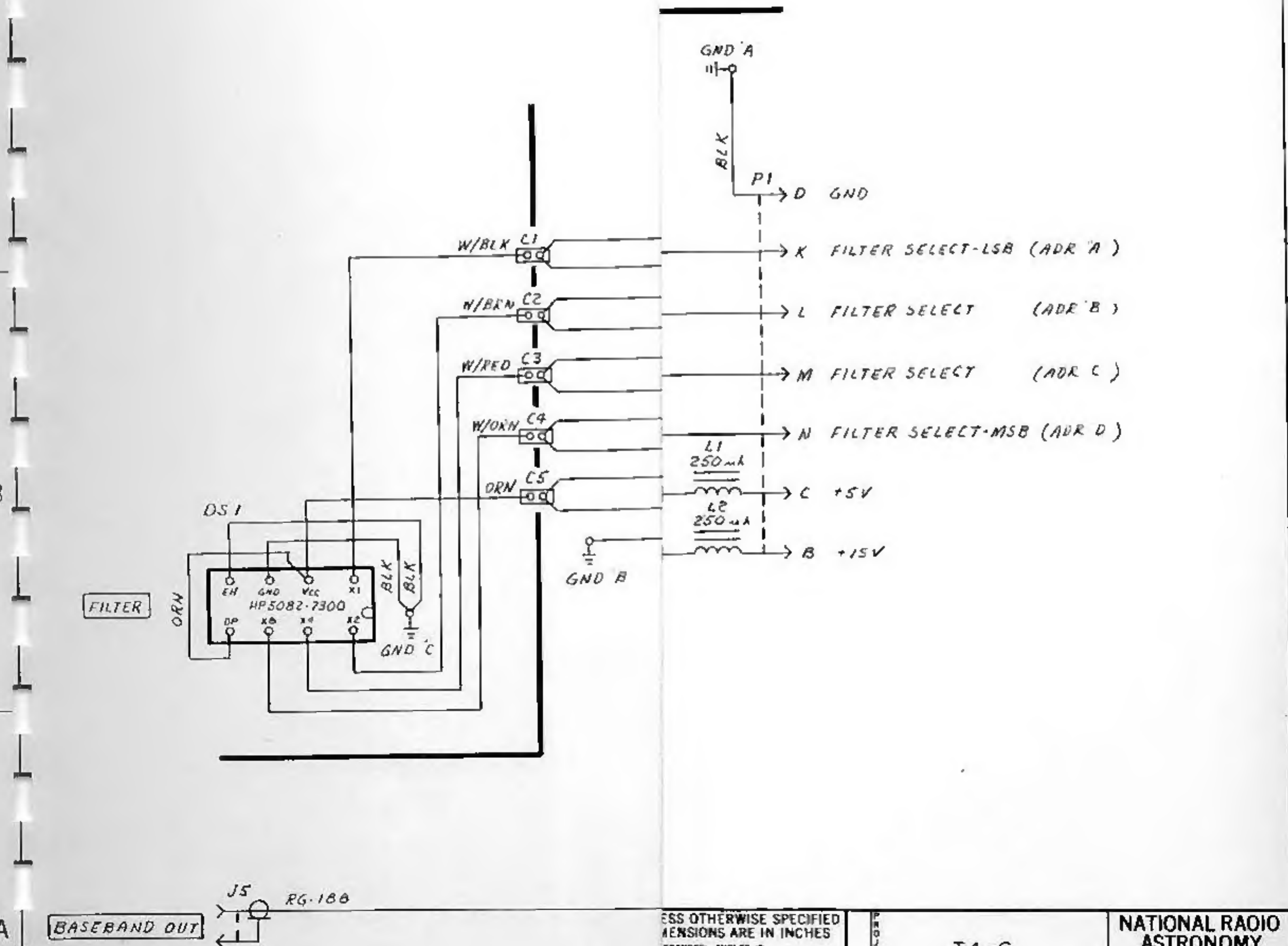
NOTES:

1. THE COMPLETE SYMBOL AND VALUE FOR C1-C11 IS AS FOLLOWS:



2. DESIGNATIONS SHOWN THUSLY [XX] ARE MARKED ON THE MODULES FRONT PANEL.





UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
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PLACE DECIMALS (.XXX) ±
PLACE DECIMALS (.XX) ±
PLACE DECIMALS (.X) ±
MATERIAL:
FINISH:

PROJECT: T4-C

TITLE: BASEBAND FILTER SCHEMATIC

NATIONAL RADIO ASTRONOMY OBSERVATORY
SOCORRO, NEW MEXICO 87801

DRAWN BY	R Rumpon	DATE 4/25/79
DESIGNED BY	W.E. DUMKE	DATE 4/25/79
APPROVED BY		DATE 4/25/79

SHEET NUMBER | DRAWING NUMBER 013820S13 | REV. A | SCALE

various digital communications system clock signals. The worst culprit, in this case, was a 10 KHz LED driver clock signal from the M2 Data Tap module. It and its harmonics could enter the module on any of the power supply buss lines common to the entire "D" rack. Since the specified bandwidth of operation in the entire baseband system is 200 KHz to 50 MHz with less than 1.5 dB peak to peak variation, and since signal levels are low in several locations, serious interference could occur in the spectral line mode which uses the narrower and consequently lower frequency filters.

A filter for general use on the T3, T4, T5 module power supply lines consists of a 250 μH low resistance choke with a 33 μFd low series resistance tantalum capacitor. This provides -30 dB attenuation at 10 KHz under worst case conditions. The capacitors are mounted on the printed circuit boards in tbe T4C and T5C modules. The chokes are mounted inside the rear module shielded compartment near the Amp connector.

The T4C and T5C module housings are unique designs that provide sheilding, optimum air flow, and excellent grounding for the microstrip and analog printed circuit boards. Maximum air flow is achieved by using the largest diameter holes consistent witb the mechanical constraints of the top and bottom rail design. The holes are small enough to also provide adequate shielding in the operating frequency range.

The modules are designed such that the PC Boards are accessible from botb sides by removing each side plate for ease in servicing. By using adjustable divider rails, PC Boards can be moved to different positions within the module. Also PC Boards of different sizes can be accommodated for versatility with possible future changes.

Microwave power transistors or hybrid amplifiers (such as those used in the T5C modules) can be readily heatsunk to the top or bottom rails using special heatsink brackets, that allow for short R.F. connections to the PC Board microstrip lines as well as low thermal resistance. These heatsink

brackets can be moved to any rail location again for versatility with possible future changes.

2.2 Filters

The specifications of the matched filters for use in the T4C baseband filter module are given in A13820N5A. Filter delay versus temperature is dependent on both "Q" and the number of poles in a filter. A low pass filter with the same out of band rejection has half the number of poles as a bandpass filter and obviously minimum Q.

Therefore, low pass filters are used for all bandwidths in octave steps with the exception of the narrowest (0.201 - .390 MHz) bandpass filter. This results from the lack of definition of the -3 dB low frequency point in the baseband system, and the performance limits of the phase shift networks in the required image reject mixer system. A bandpass filter for the 189 KHz bandwidth function overcomes these problems.

2.3 Pin Diode Switches

Two single pole - ten throw pin diode switches are utilized to select the required filter.

The Motorola MPN 3401 pin diodes are utilized because of their long storage times compared to other pin diodes which usually are not useable below 1 to 10 MHz. This storage time is not specified in the MPN 3401 data sheet, but appears to be greater than that encountered with usual microwave pin diodes.

A measurement of even order distortion @ 0 dBm sine wave input resulted in -39 dBc @ 200 KHz and -55 dBc @ 50 MHz. The actual operating condition is at a level of -20 dBm noise power. Therefore the switch distortion should be much better at the lower level, even with noise power. (Refer to WED 5/31/78)

Insertion loss for each switch is about -1 dB, with less than 0.1 dB peak to peak passband variation from 200 KHz to 50 MHz.

Measured isolation for each switch was -37 dB minimum at -10 dBm. This corresponds nicely to a predicted worst case isolation of -36 dB based on a maximum diode capacitance of 1.0 pF. Therefore total module isolation between filters will be on the order of -72 dB assuming no lay-out effects.

The lay out, however, does degrade this somewhat. The lid over the input and output microstrip runs creates a ground loop which degrades input to output isolation to -48 dB at 100 MHz with filter #7. This could be improved with finger stock on the microstrip side of the PC Board.

2.4 Filter Attenuators

Since the module operates with white noise instead of a coherent narrow band signal, the filter bandwidth causes a reduction in total power proportional to bandwidth. Attenuators, constructed of resistor "T" networks, match this bandwidth change to keep the output power constant regardless of selected filter. Thus the T5C ALC attenuator does not have to maintain low linear delay and amplitude flatness variations over as wide a dynamic range.

2.5 Amplifiers and Monitor Network

One GPD 461 and one GPD 462 are cascaded to provide 26 dB typical gain and 5 dB typical noise figure.

A -7.5 dB attenuator at the output of the GPD 462 amplifier was used to lower the level into the T5B ALC amplifier, so that it would be operating -6 dB below maximum gain for best phase stability. (The T5C module has an additional -12.5 dB at the input to the ALC amplifier to minimize compression in the ALC amplifier and following GPD stages. An additional +12.5 dB gain low compression power amplifier was added at the T5C output.)

Removal of an amplifier stage would seem more logical from a passband response and stability standpoint. However, this would make the T4C Front Panel Monitor Jack next to useless because of inadequate level, particularly in the

filter #0 position. Therefore additional attenuation was added at the input to the T5C module to provide for ease in diagnostics.

A resistor divider provides a signal -20 dB relative to the output of the module when feeding 50 Ω.

3.0 FRONT PANEL INDICATORS

3.1 Filter LED Display

Provides a decimal indication (0 - 9) of which filter has been selected by the BCD input from the T6C module.

FILTER	BANDWIDTH
0	46 MHz LPF
1	23 MHz LPF
2	11.5 MHz LPF
3	5.75 MHz LPF
4	2.88 MHz LPF
5	1.438 MHz LPF
6	0.719 MHz LPF
7	0.201 - 0.390 MHz BPF
8	External Filter*
9	Termination

* NOTE: An attenuator (or gain) is required in cascade with the external filter to match the T4C total output level relative to 0 dB @ 189 KHz.

3.2 Baseband Out BNC Connector

A resistive divider at the T4C output which provides -20 dB relative to the output when both are terminated into 50 Ω.

4.0 MODULE TEST PROCEDURE

Provide a 50 MHz LPF white noise signal at -20 dBm total power to J1 (baseband input). With a suitable power meter such as the HP 435A with 8482A thermocouple head measure the output

power at J2 (baseband output). This should be about -28.5 dBm no matter which filter position (0-7) is chosen by the attached test fixture switch box. Check the external filter position (8) by inserting 26 dB of attenuation between J3 and J4. Total output power should also be near -28.5 dBm. In position (9), the output power should drop to zero.

5.0 MEASUREMENTS

5.1 Test Setups

Test setups for amplitude and phase non-linearity versus passband are given in Figure 5.1. Because of the high accuracy desired in relative measurements between modules, it is important to use identical test set-ups each time a measurement is made. Connector and cable VSWR have been shown to have serious effects, especially in the case of relative phase measurements. However, non-repeatable errors of the order of 0.1 dB and 1.0° phase appear attainable, assuming the same cables, etc., are used each time.

Note in both cases the module performance, exclusive of the filters is measured by use of the external filter position.

5.2 T4C Passband Amplitude Response

-0.34 dB of amplitude rolloff from 200 KHz to 50 MHz is measured exclusive of the filters, for a typical module. This is shown in Figure 5.2A and B. The total amplitude rolloff for the T3, T4 and T5 module baseband amplifier system should be about -1.5 dB.

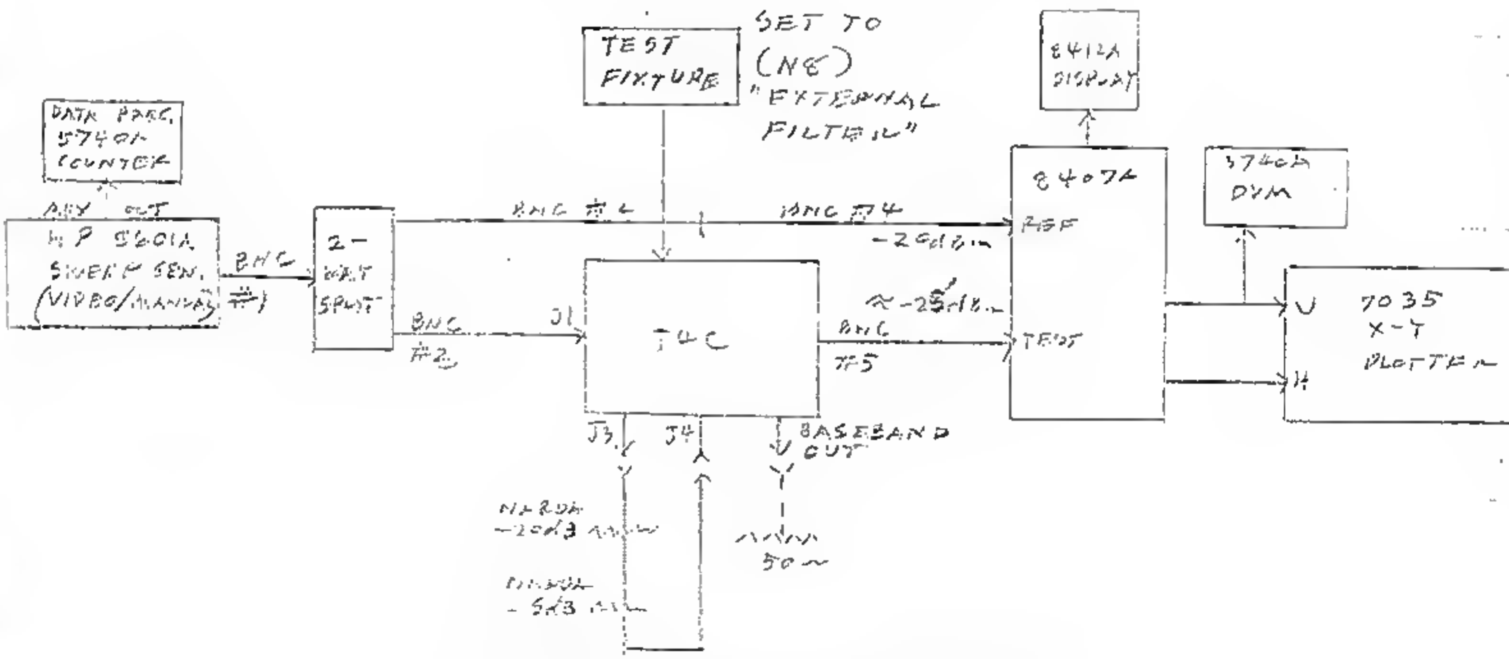
5.3 T4C Phase-Nonlinearity Versus Frequency

2.4° peak to peak phase non-linearity versus frequency from 200 KHz to 50 MHz exclusive of the filters was measured for a typical module. Since a total of 5.0° peak to peak difference in phase non-linearity from baseband amplifier system to baseband amplifier system can be tolerated, this appears reasonable. The measurement is shown in Figure 5.3A and B.

5.4 Stopband Rejection

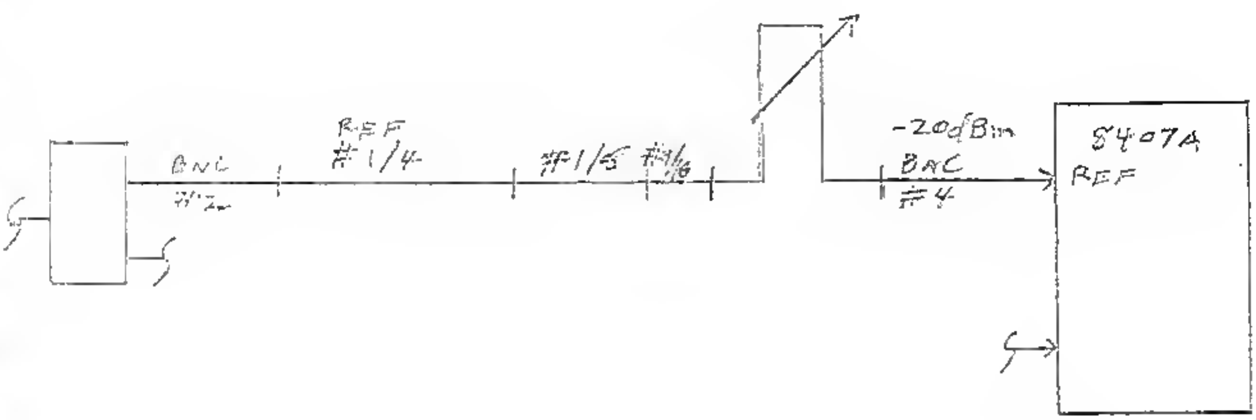
The worst stopband rejection with respect to sine wave carrier power was -48 dBc @ 100 MHz for Filter 7. This is shown in Figure 5.4A and B.

T4C Passband Response Test Set-Up



T4C Phase Non-Linearity Test Set-Up

Same as above with following changes in reference line:



(Calibrate with BNC #2, 4, 3, 5 only)

Figure 5.1

WED 7/27/79-1A

K+E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

46 0780

T4C PASSBAND AMPLITUDE RESPONSE

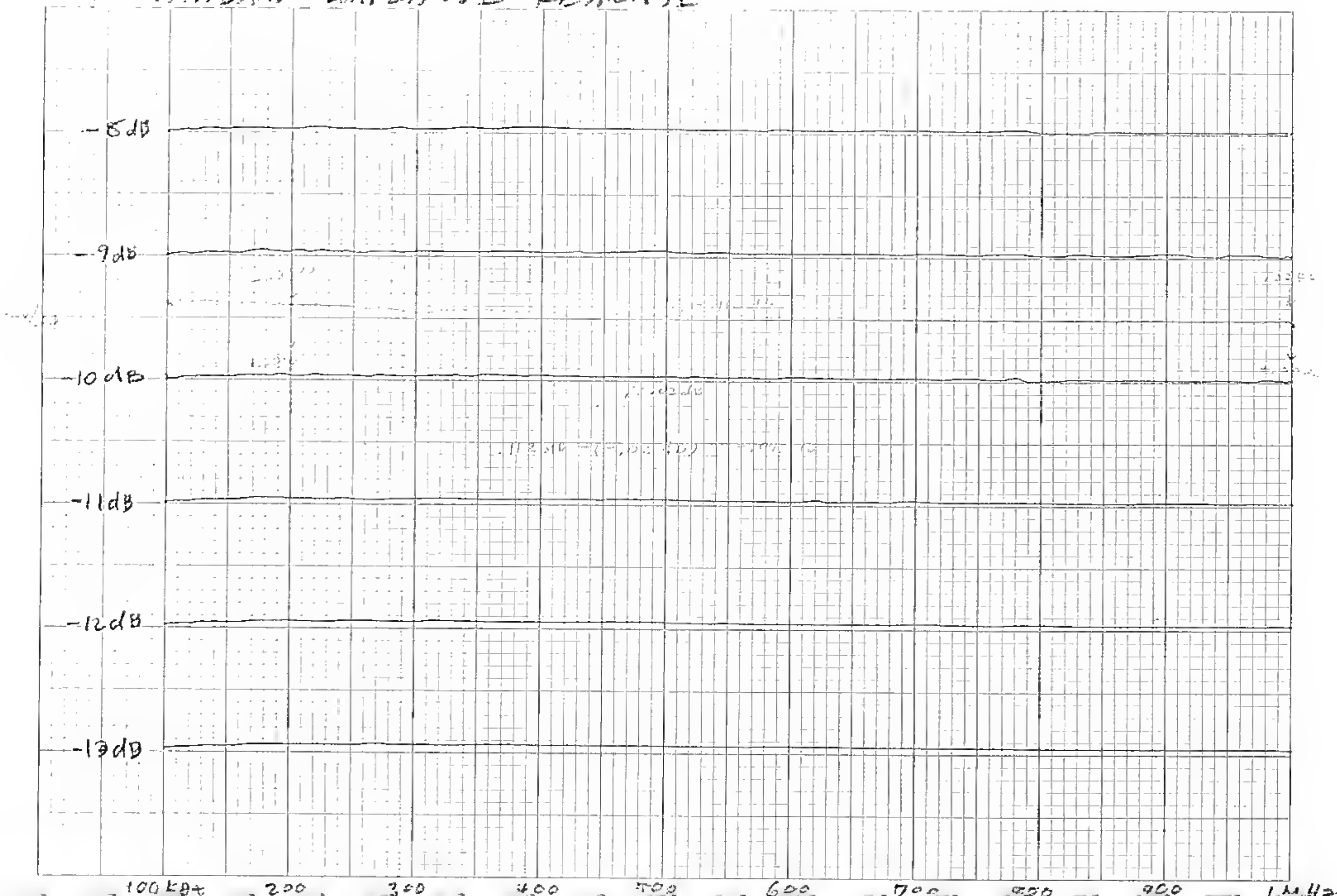


Figure 5.2A

T4C PASSBAND AMPLITUDE RESPONSE

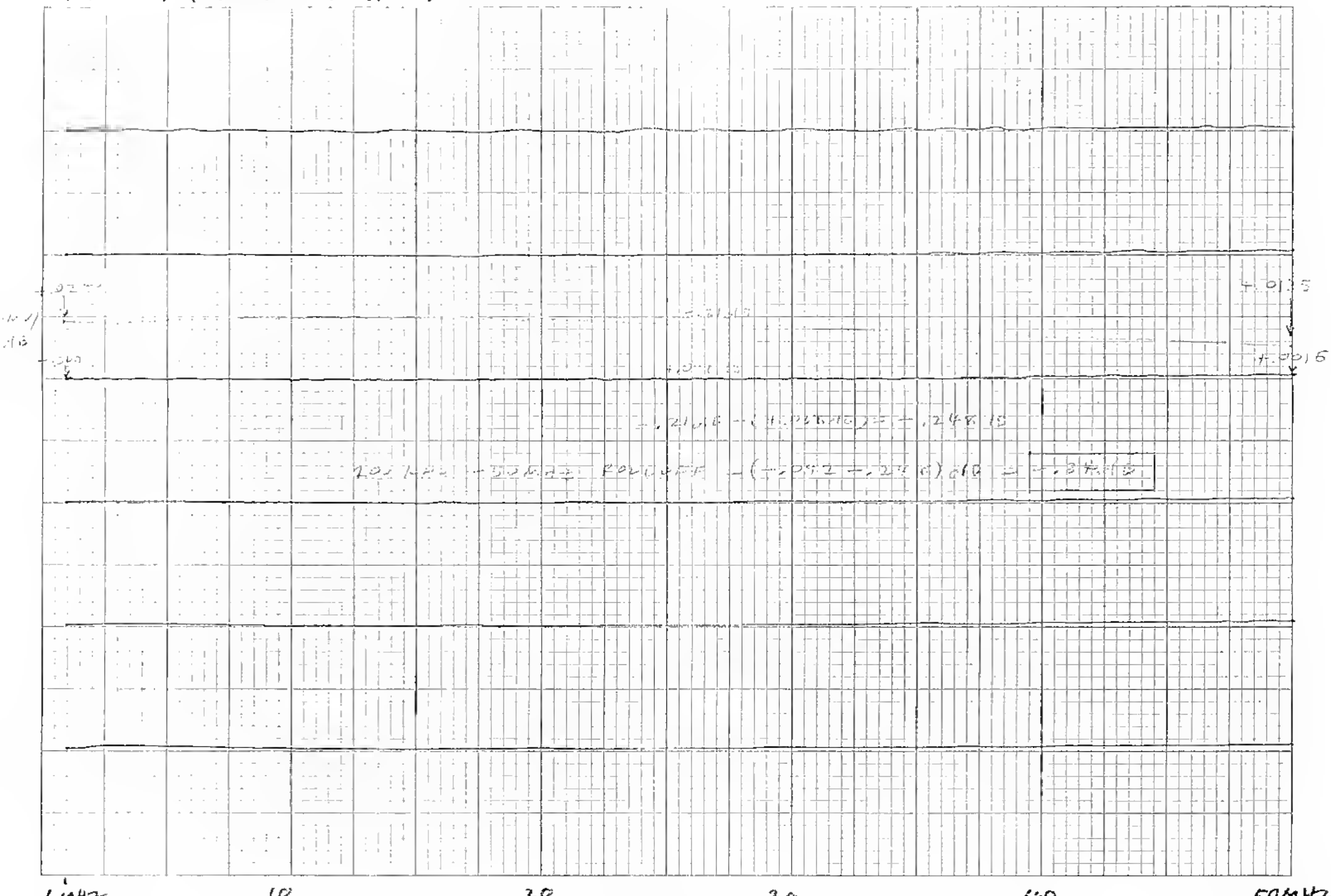


Figure 5.2B

WED 7/30/79 - 1A

T4C3 PHASE NONLINEARITY VERSUS FREQUENCY (200KHz - 50MHz)

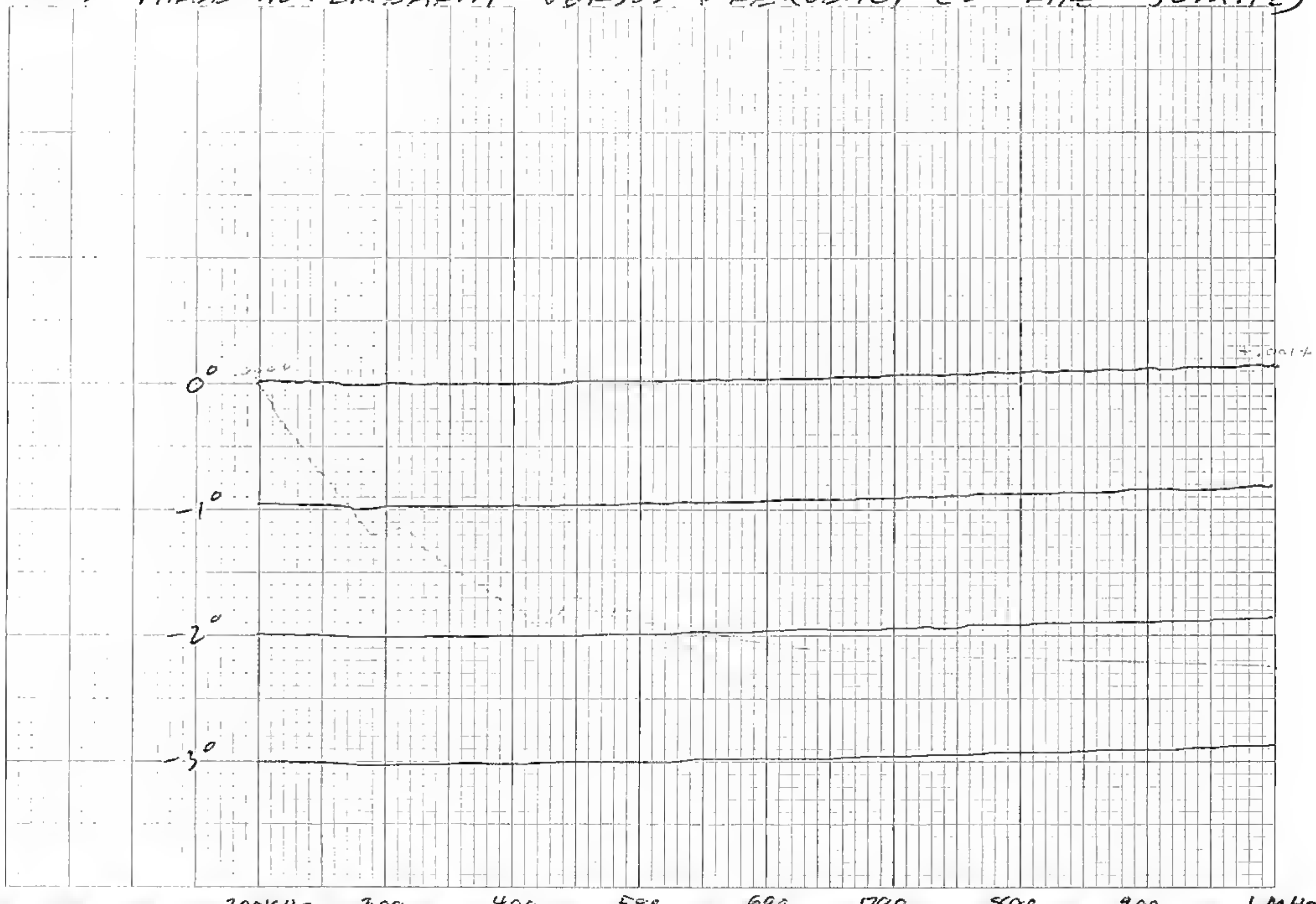


Figure 5.3

WED 11/30/74-10

K+E 10 X 10 TO THE INCH · 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

46 0780

T4C3 PHASE NONLINEARITY VERSUS FREQUENCY (200KHZ-50MHZ)

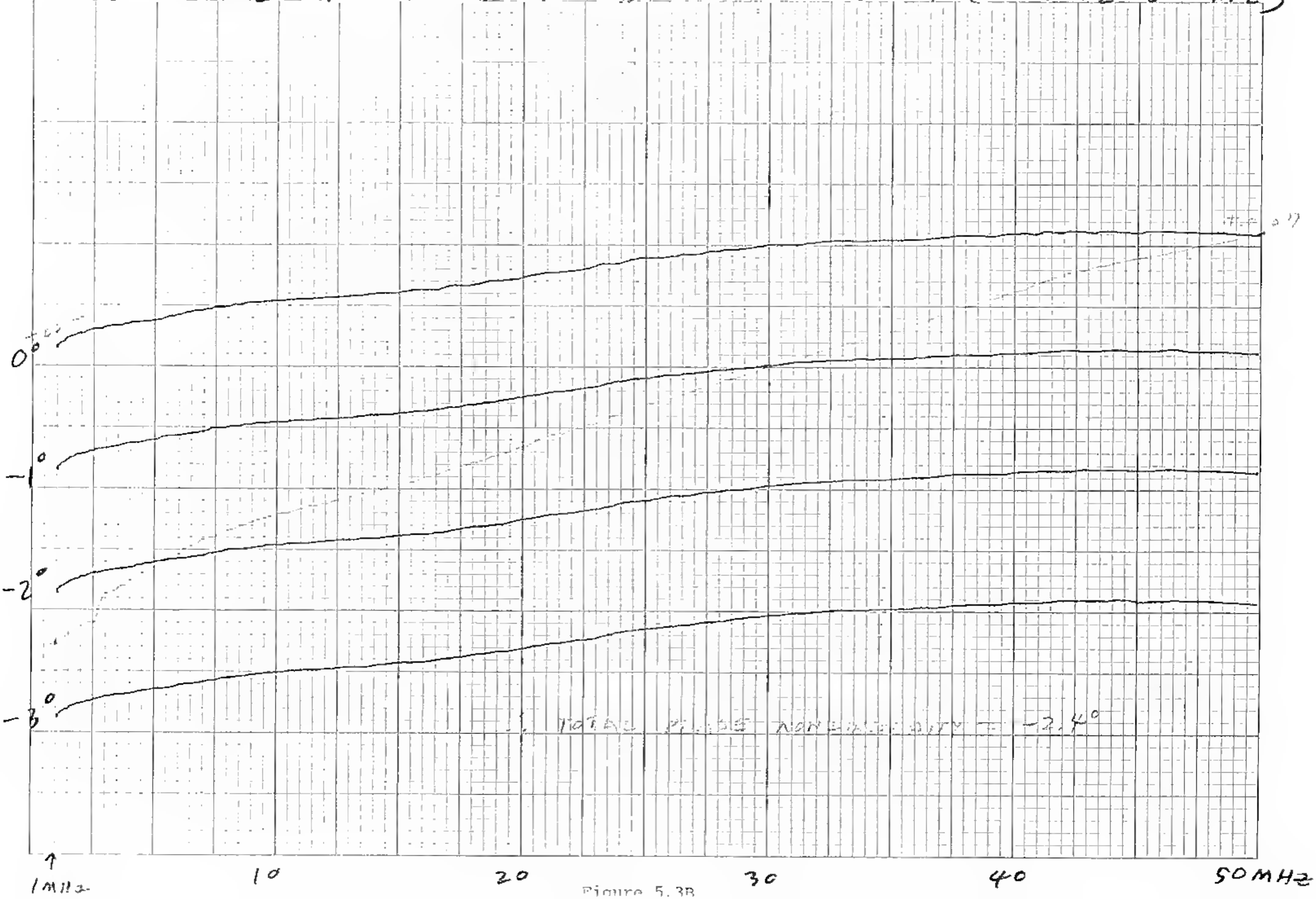


Figure 5.3B

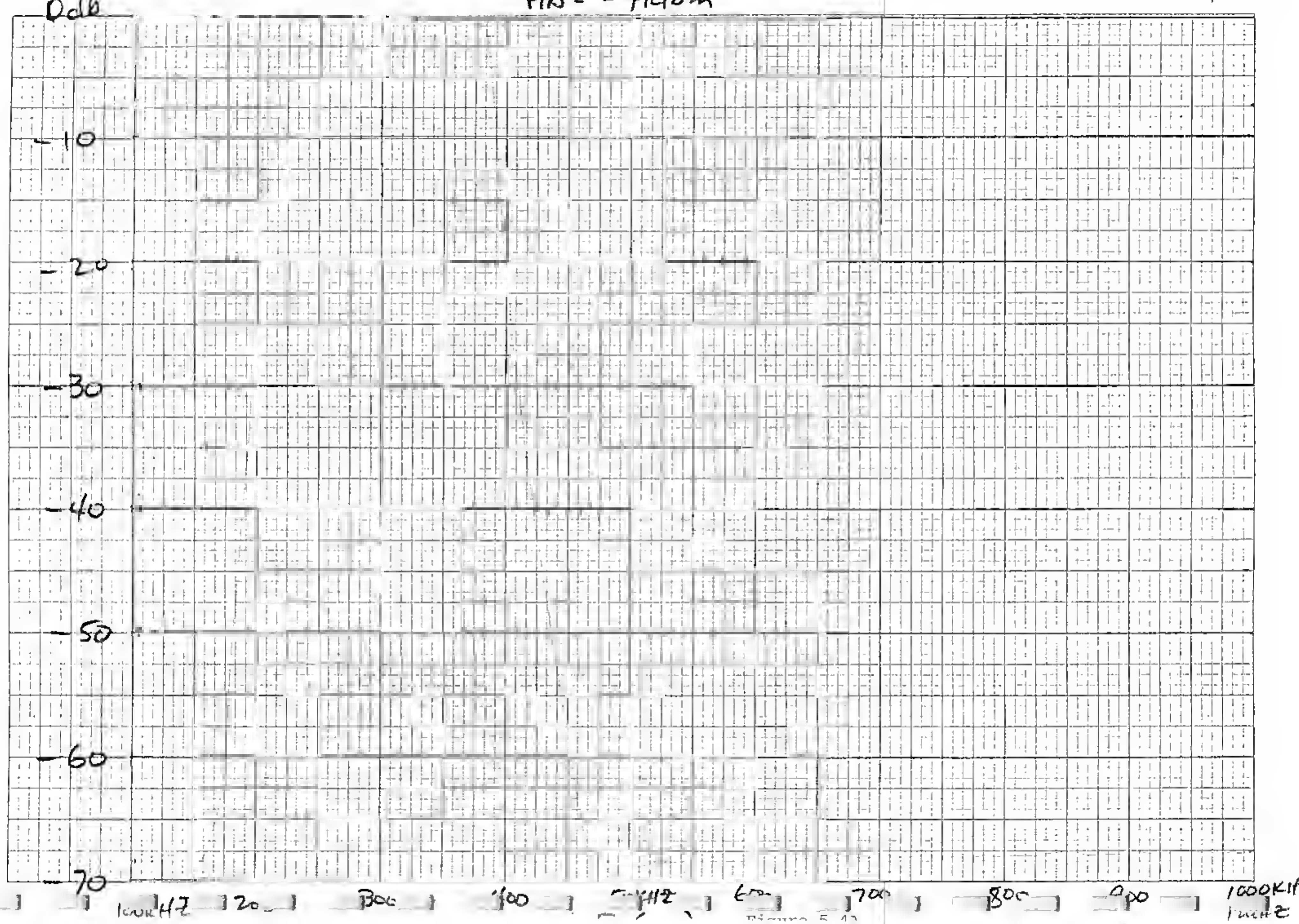
(15)

7-13-79

*

74C #3 STOPBAND REJECTION / FILTER F735-7 #0009

$P_{IN} = -41dbm$



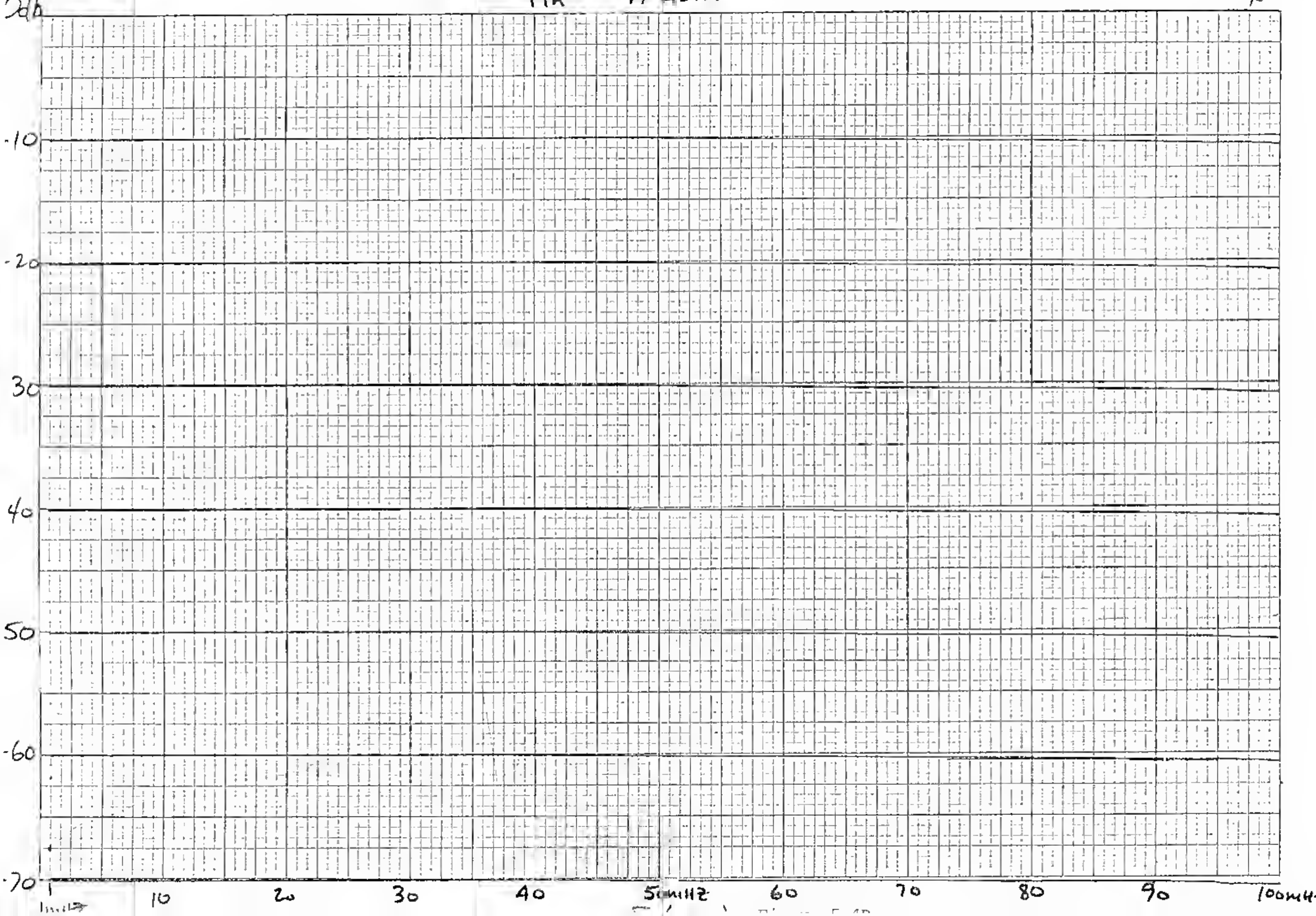
K+E 12 X 12 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 0940

(16)

T4C #3 STOPBAND REJECTION / FILTER F735-7#0009 7-13-79

P_{in} = -41 dbm

*



6.0 SPECIFICATIONS

NATIONAL RADIO ASTRONOMY OBSERVATORY
SOCORRO, NEW MEXICO
VERY LARGE ARRAY PROGRAM

SPECIFICATION: *A13820N5A DATE: July 11, 1978

TITLE: L-C FILTERS, 200 kHz TO 50 MHz BANDWIDTH

PREPARED BY: LRD APPROVED BY: PCJN

1.0 GENERAL DESCRIPTION

A series of eight different L-C filters, seven low-pass and one band-pass, is required for use ahead of a digital correlator. The filters cover a bandwidth range of approximately 200 kHz to 50 MHz. Special requirements include low temperature coefficient (Section 6.0) and matching (Section 7.0).

2.0 FREQUENCY RESPONSE

The -3 dB, -20 dB, and -40 dB cutoff frequencies for each filter are specified in Table I. Note that the -3 dB frequency is to be held to ±1% or ±2%, as indicated. The filters are all similar except for frequency scaling, and a normalized plot of the required frequency response is given in Figure 1. All attenuations are specified with respect to the zero-frequency insertion loss, except for No. 7 where they are with respect to the center-frequency insertion loss.

2.1 Passband Ripple

Over 80% of the -3 dB bandwidth, the response shall vary less than 0.5 dB (peak-to-peak).

2.2 Stopband Responses

Beyond the -40 dB frequencies specified in Table I, attenuation shall remain at or above 40 dB for all frequencies between zero and 150 MHz.

3.0 COMPLEXITY

Note that the desired responses are achievable by using

*formerly A13450N5A

a 0.1 dB-ripple Chebyshev design with N = 8 lossless elements (8 resonators for the BPF). In practice, it is expected that $N \leq 9$ will suffice. The temperature stability and matching requirements (see below) favor designs with small values of N. Note also that Section 2.2 allows designs which do not use all-pole transfer functions. The type of design and number of elements may be selected by the manufacturer, but shall be stated in any proposals submitted under this specification.

4.0 INSERTION LOSS

Absolute loss at one-half the -3 dB frequency for the low-pass filters, and at the center frequency for the band-pass filter, shall be ≤3 dB.

5.0 IMPEDANCE

The nominal source and load impedances shall be 50 ohms, and the filter VSWR at each port shall be ≤1.5 over 80% of the -3 dB bandwidth.

6.0 TEMPERATURE STABILITY

At any frequency within the -3 dB bandwidth, each filter shall have a temperature coefficient of gain of:

6.1 ≤0.1 dB per $^{\circ}$C in amplitude, and

6.2 ≤0.2 degrees per $^{\circ}$C in phase.

7.0 MATCHING

Filters for the same frequency may be ordered in batches of approximately 10 to 100 units. This Section applies to all units of the same type number (see Table I), whether or not they are in the same batch.

7.1 All units shall be of the same design (cf. Section 3.0), and shall use nominally identical components.

7.2 Over 90% of the 3 dB bandwidth, the responses of any two units shall differ by less than 5 degrees in phase and 0.2 dB in amplitude, except for Type 7 filters, which shall differ by less than 5 degrees in phase and 0.3 dB in amplitude.

7.3 Over the remaining 10% of the 3 dB bandwidth, the corresponding differences shall be less than 20 degrees and 0.5 dB.

8.0 PACKAGING AND CONNECTORS

Each filter shall be supplied in a metal case suitable for printed circuit board mounting, with input and output connections via .040-inch diameter p.c. board pins. One input pin and one output pin may be connected to the case. The height above the board shall be $\leq$0.875 inch. The case shall contain markings, readable from the top after mounting, giving the manufacturer's name or symbol, model number, and serial number.

Proposals submitted under this specification shall include the outside dimensions of each filter type.

9.0 ENVIRONMENT

All specifications shall be met at operating temperatures of 20 to 40°C, and in any orientation with respect to gravity. No degradation shall occur due to storage at temperatures of -10 to +60°C, or due to dropping from a height of one foot onto a wooden surface.

10.0 TESTING AND DOCUMENTATION

The manufacturer shall conduct such tests on each filter as he judges are necessary to ensure that all specifications are met, but in any event shall measure the -3 dB, -20 dB and -40 dB frequencies to an accuracy of 0.1%. Copies of the results of all tests shall be supplied with each filter. An outline drawing for each type of filter shall be supplied with the initial order.

TABLE I

FILTER CUTOFF FREQUENCIES

Type Number	-3 dB Frequency MHz	-20 dB Frequency Maximum, MHz	-40 dB Frequency Maximum, MHz
0	46.0±1%	52.0	63.0
1	23.0±1%	26.0	31.5
2	11.5±1%	13.0	15.8
3	5.75±1%	6.5	7.9
4	2.88±1%	3.25	3.94
5	1.438±1%	1.62	1.97
6	0.719±1%	0.812	0.985
7*	0.380±2% 0.201±2%	0.396 0.192*	0.424 0.180*

*Filter 7 is band-pass, with upper and lower cutoff frequencies given. The lower -20 dB and -40 dB frequencies are minimums. All other filters are low-pass.

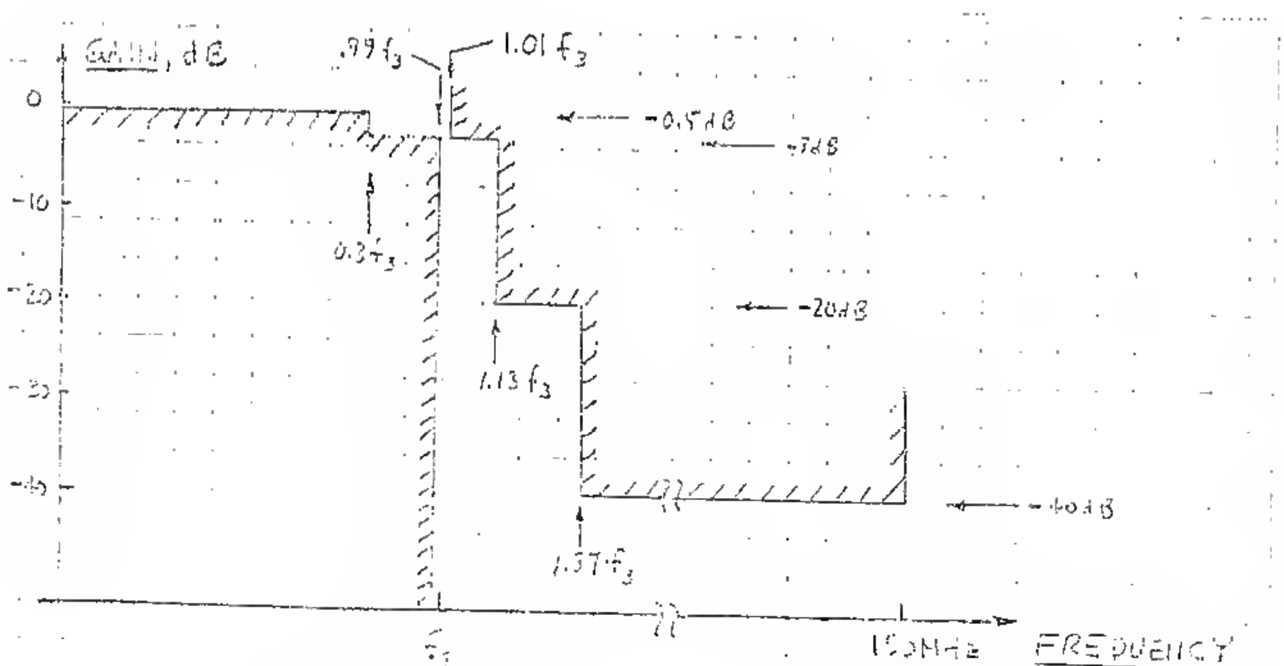


FIGURE 1: NORMALIZED LOW-PASS RESPONSE SPECIFICATION

7.0 DATA SHEETS

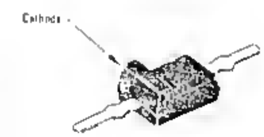
MPN3401 (SILICON)
MPN3402

SILICON PIN DIODE

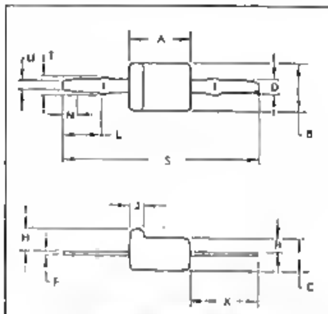
. . . designed primarily for VHF band switching applications but also suitable for use in general-purpose switching and attenuator circuits. Supplied in an inexpensive low-inductance plastic package for low cost, high-volume consumer and industrial requirements.

- Rugged PIN Structure Coupled with Wirebond Construction for Optimum Reliability
- Both 1 pF and 2 pF Devices for Design Selectivity
- Very Low Series Resistance at 100 MHz – 0.34 Ohms (Typ) @ I_F = 10 mAdc
- Low Inductance Mini-L Package
- Mini-L Ridge Clearly Identifies Cathode Lead for Easy Handling and Mounting

SILICON PIN
SWITCHING DIODE



MPN3401 – BROWN RIDGE
MPN3402 – BROWN RIDGE, RED BODY STRIPE



PIN 1 CATHODE
2 ANODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	3.41	4.11	[illegible]	[illegible]
B	2.91	[illegible]	[illegible]	0.115
C	1.91	2.16	0.075	[illegible]
D	0.61	[illegible]	[illegible]	[illegible]
F	0.01	0.11	[illegible]	[illegible]
H	1.30	1.55	[illegible]	[illegible]
J	0.61	[illegible]	[illegible]	[illegible]
K	[illegible]	[illegible]	[illegible]	[illegible]
L	[illegible]	[illegible]	[illegible]	[illegible]
N	1.12	[illegible]	0.044	[illegible]
R	[illegible]	1.04	[illegible]	[illegible]
S	[illegible]	12.15	[illegible]	[illegible]
T	[illegible]	[illegible]	[illegible]	[illegible]
U	[illegible]	[illegible]	[illegible]	[illegible]

CASE 226

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	35	Volts
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_F	400 4.0	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	–65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μA)	$V_{(BR)R}$	35	–	–	Volts
Diode Capacitance (Note 1) MPN3401 (V_R = 20 Vdc, f = 1.0 MHz) MPN3402	C_T	– –	– –	1.0 2.0	pF
Series Resistance (Figure 5) MPN3401 (I_F = 10 mA) MPN3402	R_S	– –	– –	0.7 0.6	Ohms
Reverse Leakage Current (V_R = 25 Vdc)	I_R	–	–	0.1	μA
Series Inductance (Note 2) (f = 250 MHz) (Measured at Lead Stop ≈ 1/8")	L_S	–	3.0	–	nH
Case Capacitance (f = 1.0 MHz)	C_C	–	0.1	–	pF

NOTES
1. C_T is measured using a capacitance bridge (Boonton Electronics Model 75A or equivalent).
2. L_S is measured on a package having a short instead of a die, using an impedance bridge (Boonton Radio Model 250A RX Meter).

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 – SERIES RESISTANCE

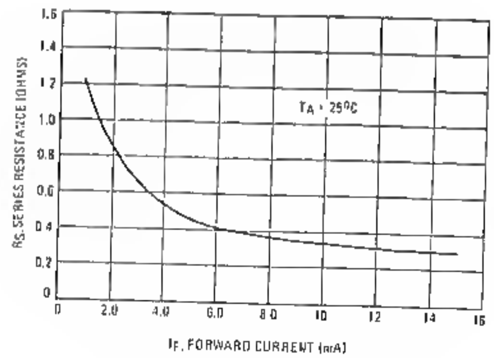


FIGURE 2 – FORWARD VOLTAGE

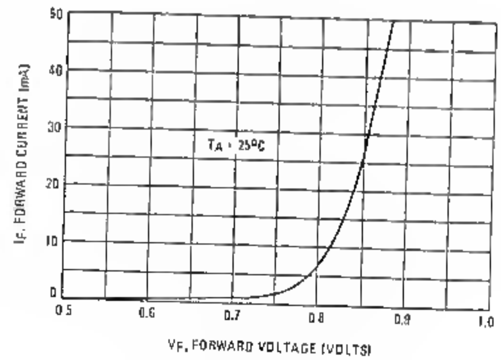


FIGURE 3 – DIODE CAPACITANCE

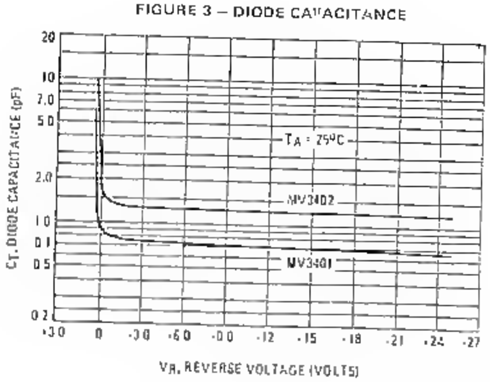


FIGURE 4 – LEAKAGE CURRENT

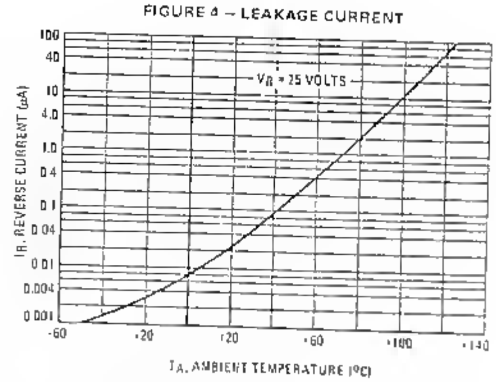
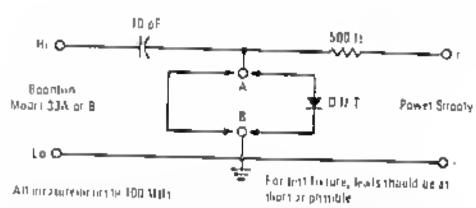


FIGURE 5 – FORWARD SERIES RESISTANCE TEST METHOD



To measure series resistance, a 10 pF capacitor is used to reduce the forward capacitance of the circuit and to prevent shorting of the external power supply through the bridge. The small signal from the bridge is prevented from shorting through the power supply by the 500 ohm resistor. The resistance of the 10 pF capacitor can be considered negligible for this measurement.

1. The RF Admittance Bridge (Boonton 33A or B) must be initially balanced, with the test circuit connected to the bridge test terminals. The conductance scale will be set at zero and the capacitance scale will be set at 120 pF, as required when using the 100 MHz test coil.
2. Use a short length of wire to short the test circuit from point "A" to "B". Then connect the power supply providing 10 mA of bias current to the test circuit.
3. Adjust the capacitance scale zero of the bridge and the "G" zero control for a minimum null on the "null meter". The null occurs at approximately 130 pF.
4. Replace the wire short with the device to be tested. Bias the device to a forward conductance state of 10 mA.
5. Obtain a minimum null on the "null meter", with the capacitance and conductance scale adjustment arms.
6. Read conductance (G) direct from the scale. Now read the capacitance value from the scale (≈ 130 pF) and subtract 120 pF which yields capacitance (C). The forward resistance (R_S) can now be calculated from

$$R_S = \frac{2.533\,G}{C^2}$$

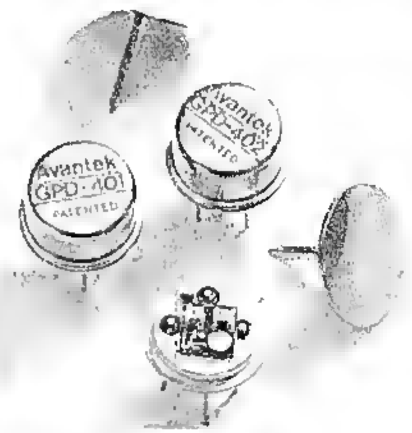
Where
G = in micromhos,
C = in pF,
R_S = in ohms

Avantek

DATA SHEET

GPD-400 Series
Patented*

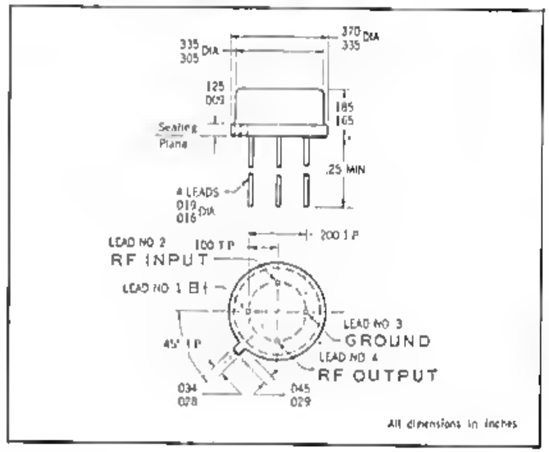
Thin Film Amplifier
5 to 400 MHz



Miniature Transistor Amplifier

FEATURES

- Low Cost
- Cascadable
- Low Profile TO-12 (4-leaded TO-5) Package
- Thin Film Sapphire Construction
- Over 6 Octaves of Amplifier Bandwidth
- Avantek Silicon Transistor Chips



DESCRIPTION

The GPD is a complete transistor amplifier, ready to operate in a microstrip circuit upon application of DC voltage. Packaged in a miniature TO-12 transistor package, the Avantek GPD serves as a completely cascadable amplifier, without bandwidth shrinkage, from 5 to 400 MHz. The low frequency response of the GPD-460 series may be set arbitrarily low by selection of external series input and output capacitors, and the DC bypass capacitor.

The Avantek GPD is an entirely new kind of basic device, designed to provide the circuit engineer major savings in both time and money. Various gain and power output choices are available to permit the user to cascade modules to meet the performance characteristics required in his equipment design. Small size, excellent performance, ready availability and substantial cost savings in equipment manufacture and parts handling are significant advantages that can be gained over standard discrete component methods of manufacture by the use of GPD amplifiers. The costly and time-consuming problems accompanying in-house amplifier design, construction and testing can be totally avoided by inserting GPD's, either singly or cascaded, into a system circuit.

The Avantek GPD is a wideband, single-stage unit of gain, featuring flat response across its greater-than-six-octave bandwidth. The tiny GPD modular amplifier is made with highly reliable sapphire substrates, Avantek microwave transistor chips, thin film circuits, thin film resistors and chip capacitors. All the complex circuitry is encapsulated inside the tiny TO-12 package. The using engineer is spared the normal frustrating RF design problems — impedance matching networks, feedback loops, biasing and stabilization elements.

APPLICATIONS:

The GPD-400 Series amplifier is designed for applications requiring very broadband amplifiers, preamplifiers, isolation amplifiers, and IF amplifiers. The patented circuit design of the GPD permits cascading of units to achieve gain up to any desired level without interstage matching when cascaded in 50-ohm systems. The specified band edges (5 to 400 MHz) are not 3 dB points, but are the points between which the specified gain performance is guaranteed. The low frequency response of the GPD-460 units may be set as close to DC as required (but not DC, for DC response see the UTD-561).

* U.S. Patent 3493882

INSTALLATION AND OPERATING INSTRUCTIONS:

Installation of the GPD amplifier is similar to the installation of any standard semi-conductor product in a TO-8 or TO-5 package. A clamp is provided to secure the GPD firmly to the ground plane. This step insures positive contact between the GPD package and the ground plane so that no problems with VSWR or oscillation in a multi-stage system will be encountered.

The GPD amplifier is designed for use in a 50-ohm microstrip system. It can be used in other impedance systems, but performance may be degraded.

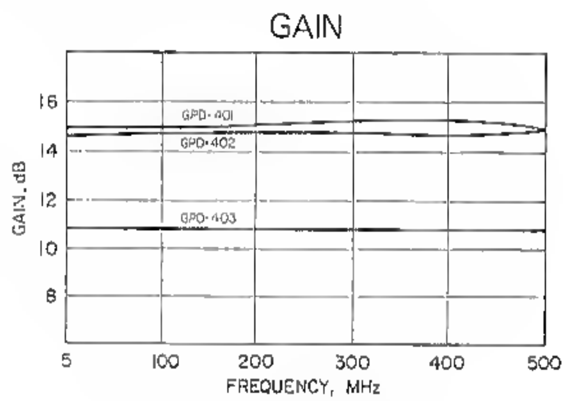
The microwave transistor used in the GPD must be protected from current surges which may be generated by energy storage in system capacitances. Always remove bias voltages from the GPD before inserting or removing the unit under test.

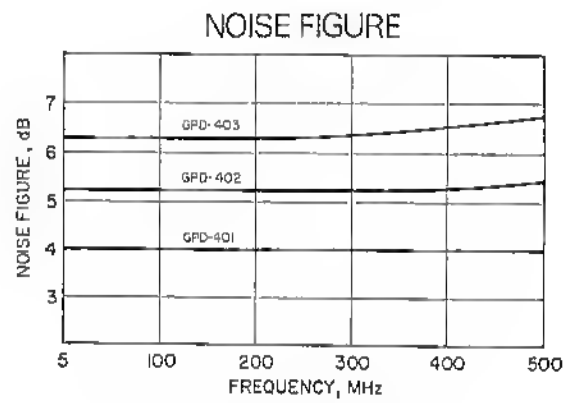
The use of a high-pass filter and/or pad is recommended at the output of gas-discharge-tube noise sources. This protects the transistor in the amplifier from possible high-level ignition-pulse transients which may appear at the RF output ports of these generators (see appropriate manufacturer's literature for further details).

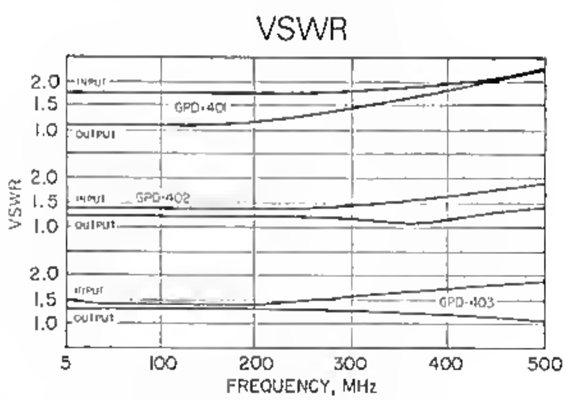
The amplifiers may be stored at temperatures from -65°C to +200°C. The transistors are silicon and all metallization is gold. The operating case temperature is specified at +71°C (+160°F). The amplifiers will operate reliably at temperatures through +125°C (+257°F) although an external heat sink should be used, particularly on the GPD-403.

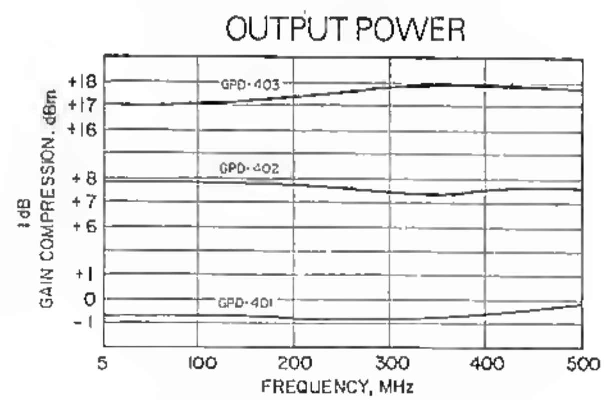
More information concerning applications and use of the GPD amplifier is available from Avantek. Write for the Applications Bulletin *Designing With GPD Amplifiers.*

TYPICAL PERFORMANCE









GUARANTEED SPECIFICATIONS

Model	Frequency Response (MHz) Minimum	Gain (dB) Minimum	Flatness (dB) Typical	Noise Figure (dB) Typical	Reverse Isolation (dB) Typical	Power Output for 1 dB Gain Compression (dBm) Typical	Avantek Intercept Point for IM Products (dBm) Typical	VSWR (50 ohms) Typical In	VSWR (50 ohms) Typical Out	Input Power Volts DC	Input Power Current (mA) Typical	Storage Temperature (°C)	Weight (grams)
GPD 401	5-400	13	1.0	4.5	20	+2	+18	2.0	2.0	15	10	-65 to +200	1.0
GPD 461	Same as GPD-401, except three external capacitors are required to establish low frequency roll-off												
GPD 402	5-400	13	1.0	6.0	20	+6	+18	2.0	2.0	15	24	-65 to +200	1.0
GPD 462	Same as GPD 402, except three external capacitors are required to establish low frequency roll-off												
GPD-403	5-400	9	1.0	7.5	20	+15	+26	2.0	2.0	24	65	-65 to +200	1.0
GPD 463	Same as GPD 403, except three external capacitors are required to establish low frequency roll-off												

8.0 DRAWING LIST

REVISIONS				
REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
A	11/8/79	Cote'	M. G. D.	RE-DRAWN BY DRAFTING

DRAWN BY Cote	DATE 10-31-79		
DESIGNED BY	DATE		
APPROVED BY	DATE	NEXT ASSY	USED ON

NATIONAL RADIO ASTRONOMY OBSERVATORY
SOCORRO, NEW MEXICO 87801

VLA

PROJECT (T4C)

TITLE BASEBAND FILTER

DWG NO. A13320C1 SHEET 1 OF 3

ASSEMBLY NAME (T4C) BASEBAND FILTER

SERIES/MODEL__

USED ON

DRAWING NO.	REV.	TITLE	NOTES
A13820ZØ4	C	BASEBAND FILTER MODULE - BOM	
D13820PØ4	D	- ASSY	
C13820DØ2	D	- BLOCK DIAGRAM	
D13820S13	A	- SCHEMATIC	
A13820NØ5	A	L-C FILTERS 200KHz to 50 MHz	
A13820W15	A	- WIRELIST	
A13820ZØ7	D	BASEBAND FILTER PCB - BOM	
D13820PØ2	G	- ASSY	
D13820SØ3	D	- SCHEMATIC	
D13820A84	E	- DRILL DWG	
D13820A83	D	- ARTWORK	
A13820Z24	—	TEST FIXTURE - BOM	
C13820F23	—	- ASSY	
B13820SØ9	—	- SCHEMATIC	
A13820Z25	—	TEST FIXTURE CABLE - BOM	
B13820P24	—	- ASSY	
C13820MØ1	D	PANEL, FRONT	
B13050M04	D	GUIDE	/
C13820MØ5	A	PANEL, REAR	
D13820MØ6	B	SIDE PLATE	
D13820MØ7	C	BAR SUPPORT, TOP & BOTTOM	

NOTES:

1. GENERAL USE ITEM

DWG. NO. A13820C1

ASSEMBLY NAME (T4C) BASEBAND FILTER		SERIES/MODEL —	USED ON
DRAWING NO.	REV.	TITLE	NOTES
D13320M09	C	DIVIDER RAILS, & PLATES	
B13320M12	A	LED MOUNTING BLOCK	

NOTES:

1. GENERAL USE ITEM

DWG. NO. A13820C1

SHEET 3 of 3

REV 1